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INVESTIGATION OF AN EXPERIENCE-JUDGEMENT APPROACH TO TACTICAL FLIGHT TRAINING: EXECUTIVE SUMMARY

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Air Force tactical flying training is one of a number of task situations where various constraints have minimized the acquisition of experience, and in turn judgement, by traditional means. Systematic phased training in synthetic environments is one way of overcoming these difficulties and was the approach adopted in this research. Due to the critical role which vision

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plays in tactical operations, the experience-judgement approach emphasized visual cues and referents. A theory of internal pilot performance provided the framework for this approach. Visual referent details were carefully defined in their relationship with complex performance. An expanded surface task analysis which stressed cues and cognitive activity started the process of categorizing flying tasks into behavioral components. Visual cues and their referents were further analyzed to develop environmental background scenes for each task through an intermediate word to picture conversion. Behavioral components were structured into instructional procedures from which behavioral goals were specified. The resulting goals and background scenes were integrated to form a phased learning plan that included event requirements, instructional techniques, and instructional features. These procedures are also applicable to other advanced training situations which have complex visual perception, decision making, and motor output requirements.

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PREFACE

How can judgement be acquired...judgement to do what is needed in a difficult and demanding situation?

As straightforward as this question is, its solution required the integration of several diverse disciplines in order to find answers. This report considered judgement, what it is, and how it could be taught in the realm of tactical flying training. Ideas and concepts were put together from several areas into a workable format which resulted in a multidisciplinary holistic approach.

Ideas came from three areas. The behavioral sciences were a major contributor for educational psychology, training technology, perception, and cognition all played roles in this approach. These ideas and concepts were tempered by the realities of the operational environment of the fighter pilot, for in the end the approach must meet their needs. The visual world of the artist also played a vital role because pilots operate predominately from visual information. The integration of artistic elements, however, was not unusual for R. B. Freeman of the Department of Psychology, Pennsylvania State University, best expressed its importance when he wrote: "It is a surprising fact that much of what we know about visual space perception is due not to the investigation of visual scientists but rather to the writings and paintings of the Renaissance artists" (1970, p. 73).

Informational gaps in various areas required the development of additional concepts. These new concepts were primarily theoretical since available experimental evidence could support alternatives. Thus, this research was a conceptual experiment where thought and analysis rather than data collection was emphasized. Validation came from internal consistency and the meeting of objectives. Based on these criteria, the experiment was successful since it defined how judgement can be acquired and structured in a phased learning environment for its acquisition.

If anything can be said about this approach, it should be that the reader not become disturbed by the departure from some traditional lines of thought. As a total view of an extremely complex training situation, the perspective was to look at the whole without the constraints of any one concept. It is anticipated that as time goes on these ideas will be refined while others may be changed; however, a start had to be made. This is that start.

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INTRODUCTION

In the past, experience has been the best teacher of judgement for demanding task situations. Now, however, in many critical work roles there is insufficient time or opportunity to acquire accurate judgement through long task related experience. For instance on the first day on the job, the nuclear power plant control room operator, the fighter pilot, or submarine commander must be ready to perform their tasks with flawless precision. They must have already gained experience and judgement through training because of increasing time or equipment constraints.

Although training methodology is of concern to many personnel, there are critical aspects which need to be addressed in the acquisition of experience and judgement. The fighter pilot, for example, operates in a visual world in which relevant cues must be extracted from a myriad of available cuing information. Thus, the thrust of this research was to determine theories of cognition and learning of sufficient depth to encompass the complex requirements of tactical flying and relate these to a visual orientation and synthetic training device* in which a pilot could develop the experience and judgement to perform these tasks.

FOOTNOTE:

* Synthetic training device is used to describe a range of training devices including simulators, operational flight trainers, part task trainers, and the like. The term provides the broadest perspective for such devices, removing the particular utilizations and limitations from specific devices.

Experience-judgement requires a comprehensive method of learning with appropriate instructional techniques and features to impart experience which will lead to judgement in the shortest possible time. While some training programs are geared towards extensive practice and participation, few, if any, provide the capability to live through something or to provide for active involvement which are the essentials of experience. Utilizing a holistic view of the tactical environment, the experience-judgement approach permits a thorough analysis and understanding of all component parts including visual cues and training procedures.

THE AREA OF APPLICATION OF THE EXPERIENCE-JUDGEMENT APPROACH

Current pilot training has been relying more and more on simulation. The synthetic environment which it offers is ideally suited to the experience-judgement approach to training. The approach outlined in this research can specify precisely what the simulator must be capable of providing. Such tailor-made environments are of concern due to the costs of simulators and the need for cost-effective training. The present day simulation philosophy tends toward high realism and fidelity in order to ensure that all cues and requirements are provided. However, it is generally recognized that high degrees of realism are not necessary for all training tasks and can even be detrimental for conflicting and irrelevant cuing information can exist. The difficulty is that there has not existed a methodology to determine what cues are actually required to perform specific tasks so that training requirements can be covered and needed experience gained.

Simulators offer the potential to structure training in ways not possible in aircraft since most flight constraints do not exist. The simulator, for example, can be initialized anywhere in space, and time can be slowed down or speeded up as instructional needs require. Other instructional features (such as computer generated prompts, examples, and feedback) can also be provided. There are, however, real and perceived drawbacks to synthetic environments from a pilot's perspective. The simulator is not an actual aircraft and cannot exactly reproduce the flight environment.

Hence, motivation can be a problem unless pilots find that their skills can be honed faster and with less frustration in the simulator, making their actual flight time more productive and enjoyable. Overall then, effective utilization of synthetic training devices requires the development of an experience-judgement approach which structures both training events and the devices in which these events are taught. Thus, systematic training in a synthetic training environment is what this research is about.

THE EXPERIENCE-JUDGEMENT APPROACH

Experience and judgement are closely tied together so the phrase, experience-judgement, was developed to express this relationship. Experience was defined as the skill or understanding which is the result of living through something or the practice of, or participation in something. Judgement is a term frequently used in flying. For instance, it is said that a pilot must be a good judge of distance and must exhibit good judgement in complex flying tasks. The judgement of distance based on perception does not use the same mental processes as making judgemental decisions in complex situations. Thus, two types of judgement, spacial judgement and organizational judgement, were identified as expressing the cognitive and informational processing aspects of tactical flying. The concept of spacial judgement is based on the knowledge pilots use to deal with and react to perceptual cues, and is defined as the synthesis of perceived information which is used to estimate flying conditions in real time situations. Organizational judgement is the basis of the intellectual requirements of flying and is defined as the synthesis of learned knowledge and perceived information in order to make decisions or form conclusions about real time flying situations.

This research determined an information processing and learning theory which would accommodate spacial and organizational judgement in the complex and dynamic environment of the fighter pilot. Figure 1. shows the basic components of the experience-

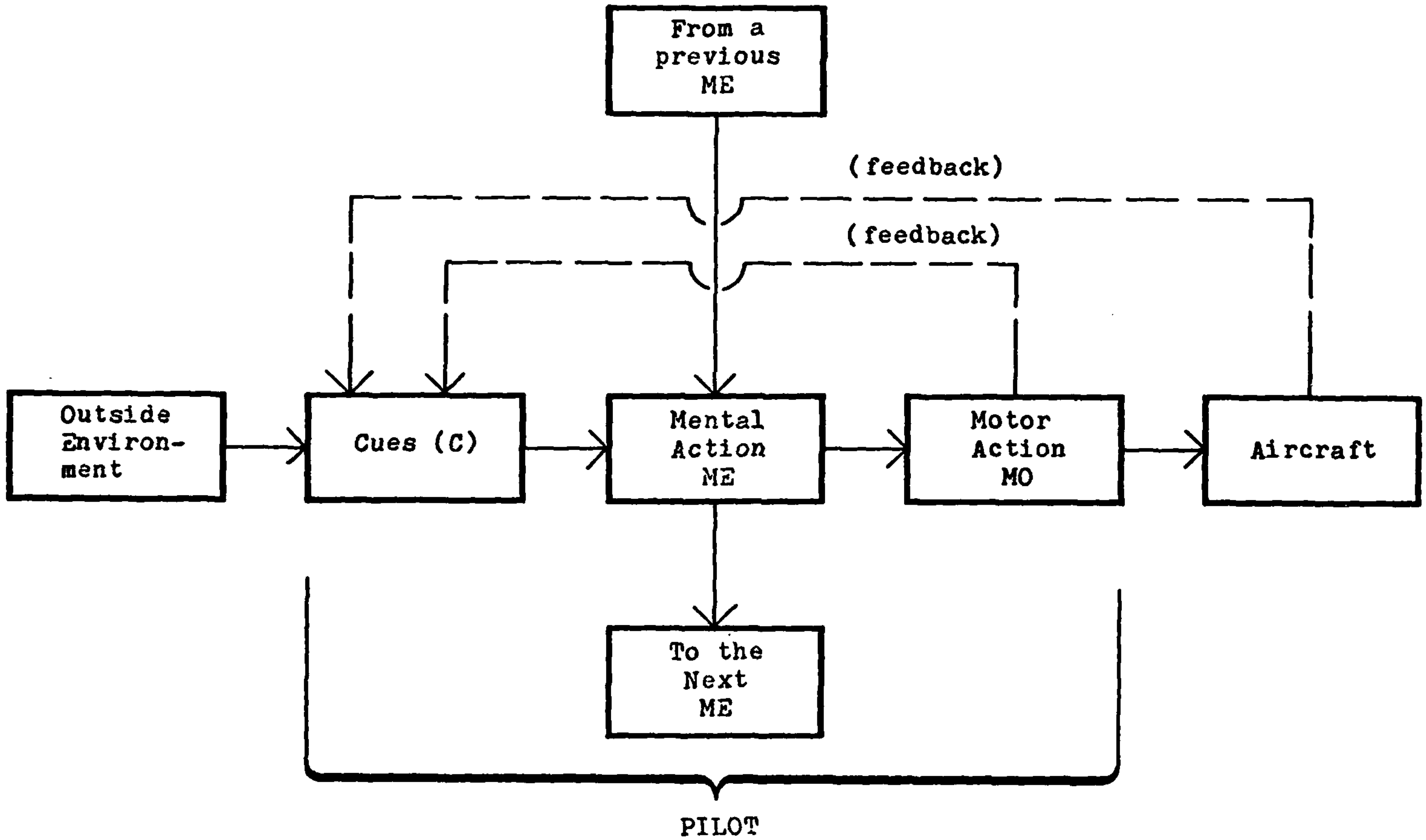

Figure 1. Experience-Judgement Theory

judgement theory. The environment of the fighter pilot is a highly visual one where visual cuing makes up over eighty percent of all information processed about the task. Thus, a visual philosophy was developed to provide a foundation for this visual emphasis and allowed the consistent description and accurate analysis of visual cues within a specific flying task. These cues were divided into basic groups. An example of this classification can be seen in Table 1. which shows background environment cues divided into sky, horizon, and ground cues. Visual elements, called referents, were also defined which encompassed a further description of all visual cues.

Visual cues and referents make up one part of the cognitive portion shown in Figure 1. An expanded task analysis was developed which accommodated the remaining cues, and the mental and motor actions of a tactical flying task. This analysis considered the cues and mental actions as the pilot component of a pilot-aircraft-environment interaction. These components form a comprehensive theory of how pilots operate and became the basis for the task analysis.

The expanded task analysis format for the Low Angle Dive Bomb is presented in Figure 2. The categories for the analysis are:

1. Cues and Cuing Referents - Cues are divided into visual, aural, control, and motion cues. Due to the visual nature of the piloting tasks, visual cues are analyzed in greater detail than the other cuing types.

Table 1. Background Environment Cues

Sky Cues

Aerial Layout

1. Sun
2. Skytone
3. Cloudforms - weather clouds, precipitation, haze, etc.
4. Targets - aircraft, aerial missile types
5. Weapons Discharge -(transitory) flak, missile trails, tracers

Horizon Cues - Skytone/cloudforms, profile

Ground Cues

Surface Layout

1. Patterns - cultivation areas, flora/vegetation areas, geological formation areas, bodies of water
2. Profiles - hills, flats, mountains, valleys
3. Landmarks - all prominent patterns and profiles, i.e., lakes, river courses, shoreline, islands
4. Checkpoints and IPs - all conspicuous patterns and profiles, and roads, highways, rail lines/ intersections, towers, tanks, bridges, dams, power stations, monuments, cities, towns, villages, airfields, strip mines
5. Targets - (strategic) roads, highways, rail lines, towers, tanks, bridges, dams, industrial areas, power stations

   Targets - (tactical) weapons emplacements, command posts, ground forces, communication centers, supply dumps, airfields, armored and supply vehicles, barges, ships
6. Weapons Discharge - (transitory) missile launches, muzzle flashes, tracer flashes, smoke, dust, cast shadows

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2. Cuing Activities - This category describes the essentials of each cue and referent found in the task sequence in terms of usefulness. Eight cuing activities have been established and are related to specific cuing types.

3. Mental Actions - Cues and referents, which are perceived/ selected by the pilot result in various types of information. Four types of information processing involving short term and long term memory are described by specific action verbs.

TASK NO. 2a TASK Low Angle Dive Bomb/Controlled Range DATE December, 1979

SEQ.	CUES AND CUING REFERENTS	CUING ACTIVITIES	MENTAL ACTION	MOTOR ACTION
A.	Sequence Goal: ESTABLISHED ON DOWNWIND TO TARGET			
	Visual — Sky			
	*Skytone-(color & gradient)			
	*Lead Aircraft-(size, shape, perspective) to ownship	*Range & Tracking in pattern*		
	Horizon			
	*Skytone-(color & gradient)			
	*Profile-(shape & contour -Horizontal Constant) to ownship	Movement (attitude) & Direction		
	Ground		Determines proper spacing from lead & distance from target	
	*Target-(shape, size, contrast, contour, perspective) to ownship	Range, Direction & Location		
	*Patterns-(shape, size, contrast, contour, perspective - Vertical Construct) to ownship	Movement & Direction	Sustains level flight	
	*Landmarks-(*shape, size, contour*, contrast, perspective) to ownship	*Identification &* Location		Maintains required aileron & stabilator control
	Aural-Normal aircraft sound	Stable Reference Info.		
	Control-Aileron & stabilator pressure	Support Feedback		
	Motion-Normal g	Support Ref. Feedback		

COGNITIVE REQUISITES

Spacial Judgement	Organizational Judgement
Discrimination - to distinguish target location from terrain features and lead aircraft	Data - range procedures, altitude, airspeed and weapons system procedures
Angular Concepts - Recognition of relative geometry of target and position in pattern relative to lead aircraft	Strategy - initial selection of bomb pattern and ranking possible alternatives, rules of thumb to achieve bombing accuracy

Figure 2. Expanded Surface Analysis Format Example

4. Motor Actions - This category describes the output of the mental activities in terms of the pilot's actions on the aircraft flight control system or subsystems in each task sequence.

5. Cognitive Requisites - This category shows the critical judgement factors which are essential to the performance of a particular action sequence in the expanded surface analysis. There are two categories of cognitive requisites which reflect the type of flying situation.

Behavioral goals were extracted from the expanded surface task analysis mental action category in order to determine training event requirements. The event requirements were coupled to a learning plan developed from a review of learning theory and instructional technology. In this manner, it was possible to systematically structure training into a phased approach.

Concurrent with the behavioral goal extraction, a visual conversion process was applied to the visual cues to change them to a form compatible with visual design requirements for actual scene development. A "word-picture" format was developed in which the event scene to be developed was expressed in compatible word terminology. Four input areas were considered essential to the development of "word-pictures" which contained sufficient depth to create useful task oriented information. These are:

1. Visual Data Summarization
2. Visual Data Check
3. Geomorphic Considerations
4. Tactical Implications

An example of visual data summarization for the Low Angle Dive Bomb is shown in Table 2.

Table 2. Visual Data Summarization of the Low Angle Dive Bomb Task

Cues-	Cuing Referents
Sky-	
Skytone	Color, Gradient
Lead Aircraft	Shape Size Perspective
Horizon-	
Skytone	Color, Gradient
Profile	Shape, Contour Horizontal Constant
Ground-	
Patterns	Shape, Contour Size, Contrast Perspective Vertical Construct
Target	Shape, Contour Size, Contrast Perspective
Landmarks	Shape, Contour Size, Contrast Perspective

With the development of the "word-picture", the visual designer was in a position to sketch examples of the appropriate visual scene. To do so, two factors were considered: the level of stylization and the geomorphic considerations. Level of stylization replaces "realism" which is too imprecise for proper scene description.

Stylization is defined as the portrayal of useful and essential visual elements of an object relative to the object's identification. The concept is illustrated in Figure 3. with an

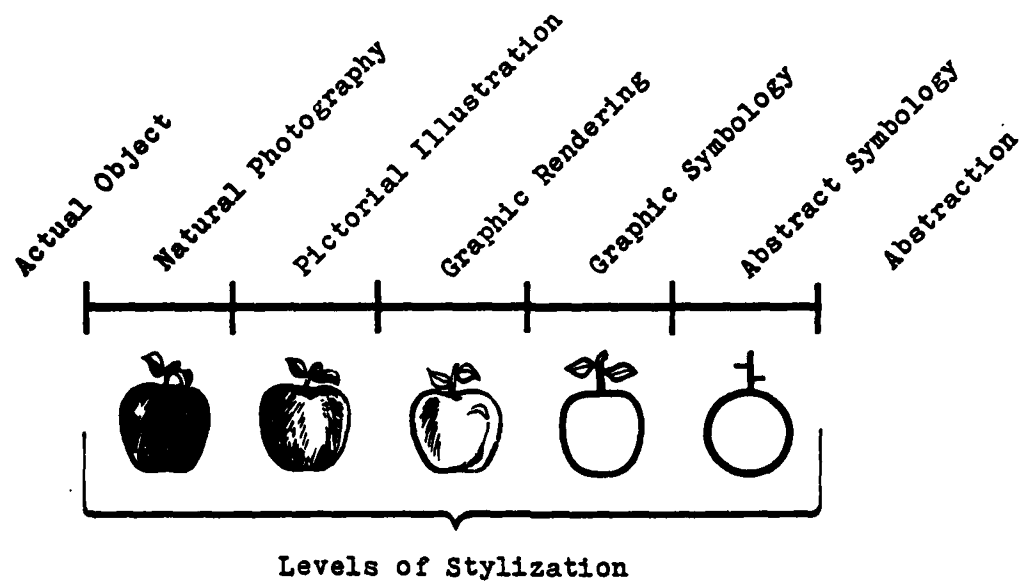

Figure 3. Five Levels of Stylization

apple "object" and shows that only the actual object conveys ultimate realism becoming the standard reference for the properties of visual identification. The levels of stylization involve not only the removal of detail, but also the simplification of visual elements or referents - notably those of shape, contour, and texture.

Geomorphic considerations are concerned with the type of terrain to be used in the scene. Each type of terrain has different attributes which need to be considered. Different renditions in terms of stylization and geomorphic considerations are presented in Figures 4. and 5. Although each scene appears different, all scenes contain the same visual cuing information illustrating the diversity of possible scenes.

Figure 4. Topographic Area with Simplified Referents

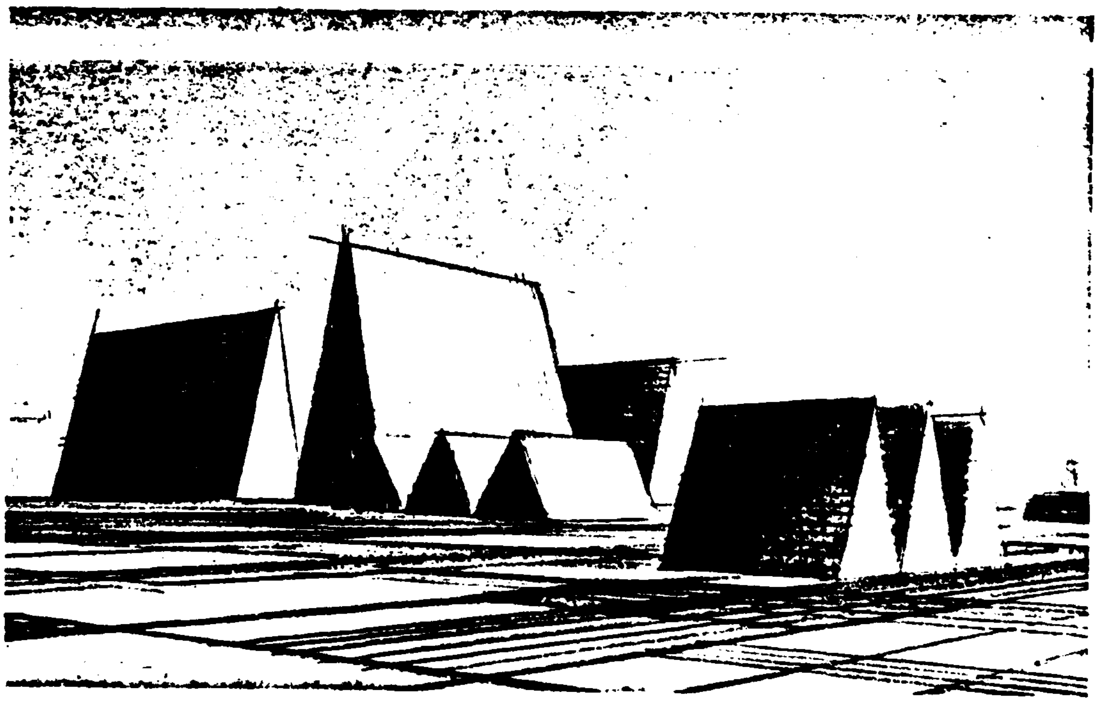

Figure 5. Mountain Periphery Detail as Graphic Symbology

The particular scene to be used must consider the behavioral goals and their corresponding training event requirements in a phased approach to learning. Many alternative scenes are possible, but only a limited number will match the behavioral goals and specific event requirements. To an extent, the specific visual capabilities of the synthetic device also must be factored into the scene selection. The end result is an integrated training package utilizing the synthetic device capabilities to the fullest.

CONCLUDING STATEMENT

The experience-judgement approach provides a useful means of developing tactical training concepts for fighter pilots. Based on a theory of how pilots perform, a task analysis approach led to the development of behavioral goals and training requirements including the specification of the visual environment. These goals and requirements provided the basis for the rational design of synthetic device features.

This approach is the first attempt to integrate the visual and training requirements of complex operational tasks. As such, the approach has not been validated and the actual implementation in terms of hardware for a synthetic device remains to be done. There is no reason to expect any great difficulty in performing the additional research and testing necessary to verify the approach.

Wherever experience and judgement must be gained without long on the job training, the experience-judgement approach appears to be feasible. Neither the theory of how pilots operate, or task analysis is exclusive to flying tasks. Many other related jobs (such as tank commanders, submarine captains and nuclear plant control room operators) also require similar types of experience and judgement. There is wide potential for the employment of this approach.

PREVIEW OF FINAL REPORT

The final report consists of seven sections and a separate appendix section. It is suggested that the reader review the Overview before proceeding with other sections. The Overview provides a statement of the problem, the research goals, and a summary of the approach used. Those interested in understanding the basic nature of how a pilot operates should continue with Section 1 - The Experience-Judgement Theory which sets the stage for the rest of the report.

The researcher interested in visual cuing and related referents should read Section 2 - Visual Cuing in Complex Task Performance which identifies the basic attributes of cues and referents. The visual emphasis continues in Section 5 - The Visual Conversion Process which develops the "word-picture" and lastly Section 6 - A Visualization Methodology which considers the stylization and geomorphic aspects of scene development.

The trainer interested in task analysis and taxonomic issues should read Section 3 - Expanded Surface Task Analysis which defines the analysis procedures. The researcher interested in the integration of task analysis and learning should read in addition to Section 3, Section 4 - Instructional Review which defines specific behavioral goals associated with the analyzed tasks.

The final melding of visual and training aspects occurs in Section 7 - Experience-Judgement Learning Plan with a comprehensive statement of two analyzed training tasks. Supporting details for all analyses are located in the appendix.

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